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Technical Memorandum

Date: April 2006
From: NASA/City of Pasadena
To: Department of Health Services, Drinking Water Branch, Los Angeles Region
Subject: Redundancy of Air Stripper Unit for the City of Pasadena's Monk Hill Treatment System

1.0 Introduction

This technical memorandum has been prepared to address the usefulness (or lack) of the existing air stripper unit as a part of a treatment train for the future Monk Hill treatment system. The air stripper unit has been used in the past to remove the Volatile Organic Compounds (VOCs) from four City of Pasadena's adjacent extraction wells. This memorandum is an attempt to explain the effectiveness of the liquid phase granular activated carbon (GAC) technology for removal of VOCs from groundwater and therefore, the redundancy for another technology to remove the VOCs as a part of the Monk Hill treatment train.

2.0 Treatment Technologies

The two treatment technologies compared in this memorandum are liquid phase GAC technology and air stripping technology.

2.1 Liquid Phase Granular Activated Carbon

If the GAC is designed based on the assumption that the Calgon air stripper system will not be treating the extracted groundwater for VOCs, then it will have to effectively remove the VOCs from groundwater in order to satisfy the absence of an air stripper unit in the treatment train. The general requirements of such a system are as follows:

- The GAC system will treat groundwater from four wells at an operational flow rate of 7,000 gallons per minute (gpm), and will be part of a drinking water treatment facility.
- Groundwater is part of a CERCLA operable unit. Therefore, the spent carbon will be handled in accordance with the Off-Site Rule (40 CFR 300.440).
- The GAC system will be designed for the anticipated influent contaminant concentrations and treatment objectives defined in Table 1.

Table 1. Estimated Influent Water Quality to LGAC System

Chemical	Concentration	Treatment Objective
Trichloroethene	20 μg/L	<2 μg/L
Tetrachloroethene	8 μg/L	<2 μg/L
1,2-Dichloroethane	2.5 μg/L	<0.2 μg/L
Carbon Tetrachloride	20 μg/L	<0.2 μg/L
1,2,3-Trichloropropane	0.014 μg/L	<0.005 μg/L

A comparison of carbon usage rates for each of these chemicals have been performed through a series of computer models that were developed to predict the number of days of service that can be expected from the primary (lead) adsorber unit operating in series with a secondary (lag) unit. The comparison examined the change in usage of the combined VOCs (TCE, PCE, 1,2-DCA, and CCl_4) versus the same four VOCs and 1,2,3-TCP. Change out of the lead unit was based on the effluent water measured between the two adsorber beds reaching the target concentration of the controlling (or "driver") compound. The modeling results from 3 different carbon vendors are provided in attachment 1. Based on these results, 1,2,3-TCP at its maximum concentration does not significantly effect the usage of carbon. The increase of the carbon usage for a virgin coconut shell type due to 1,2,3-TCP presence from the 3 vendors are:

- U.S. Filter: 12%
- Calgon Carbon: 3%
- Shaw/Basin: 3%

Virgin coconut has been used to run this comparison since this type of carbon was the only common type used by all 3 models . According to the modeling results the primary compounds in the water that will be using the highest amount of carbon are CCl_4 and 1,2-DCA. The models differ on the which compound has the highest GAC consumption (CCl_4 in U.S. Filter and Calgon models, and 1,2-DCA for Shaw/Basin model). However, there is a general agreement that two factors are involved in determining the "driver" compound: 1) concentration and 2) adsorbability. In this case CCl_4 concentration is an almost an order of magnitude higher than 1,2-DCA; however CCl_4 also has higher adsorbability on activated carbon. The combination of these two factors in the field will be determining which one would be the real driver. In either case, none of the models indicate that 1,2,3-TCP would be the driver compound.

The GAC technology is capable of removing a wider range of chemicals from water than a traditional air stripper unit. 1,2,3-TCP can be removed very effectively by GAC while due to its low vapor pressure can be poorly removed by air stripping (3.4 mmHg for 1,2,3-TCP, versus 87 mmHg for 1,2-DCA and 72.6 mmHg for TCE @ 25 ^{o}C). Since the existence of this compound dictates the need for a GAC system, the idea of using the GAC technology to remove other target chemicals seems not only logical but also attractive.

2.2 Air Stripper

One of the disadvantages of using the air stripper unit is that the stripping process results in a decrease in the carbon dioxide content of the treated water. This phenomenon causes an increase of the water pH that can lead to precipitation of calcium carbonate. Should the air stripper become part of the Monk Hill treatment train, its geographical location dictates that it becomes the first unit in the treatment train configuration. Therefore, the effluent of the air stripper unit will become the influent of the ion exchange (IX) system. IX units, just like any other packed column technology, are highly sensitive to clogging.

In order to deal with this problem, the pH of the air stripper effluent water has to be reduced before it enters the IX units. This can be done by direct addition of an acidic compound to the effluent water. Due to high flowrate of water for this plant (7,000 gpm), significant quantities of acid has to be added to the effluent water. Besides the additional cost of the acid and the equipment and resources for storage and addition of it, there are problematic issues such as approval of storage of a large volumes of a hazardous material in the middle of a residential neighborhood, and the potential dangers to the neighbors in case of an accidental release and the consequent legal challenges that the entity in charge of the plant operation may face.

3.0 Two Lines of Defense

The ultimate purpose of this treatment unit is to provide clean water that meets the regulatory standard for drinking. This increases the sensitivity of meeting the treatment objectives and warrants the desire to provide more than one way to achieve the goal. The GAC technology which in either scenario (with or without air stripper) will have to be used as a part of the treatment train (for removal of 1,2,3-TCP) will provide a second line of defense to remove the unwanted chemicals from the water. In one scenario, this role will be played as a polishing stage to remove 1,2,3-TCP and other remaining trace chemicals after the air stripper and the IX units. In a scenario with no air stripper, it can perform as a multilayer filtering unit for removal of 1,2,3-TCP, VOCs, and other trace chemicals through designing the adsorber beds in series.

4.0 Conclusions

Although the existing air stripper unit is an effective tool in removal of VOCs from groundwater, it does not qualify as a necessary part of the future Monk Hill treatment train:

- GAC technology is capable of removing 1,2,3-TCP in addition to all the targeted compounds that air stripper removes with only 3 – 12% increase of the annual carbon usage
- Using air stripper can result in precipitation of unwanted chemicals and clogging of the IX and GAC beds
- Using air stripper will require unnecessary exposure of the nearby residential area to hazardous chemicals stored at the site and the potential of their accidental release
- GAC can safely provide more than one line of defense for removal of VOCs from groundwater
- GAC is approved for drinking water systems throughout the U.S. for safely removing VOCs including 1,2,3-TCP.

ATTACHMENT 1

ISOTHERM MODELING RESULTS FROM

- **U.S. FILTER**
- **CALGON CARBON**
- **SHAW/BASIN WATER**

WESTATES

April 5, 2006

Monk Hill Treatment System

Annual GAC Usage Rates for Treating 7,000 gpm of Monk Hill Groundwater. These usage rates assume the particular contaminant controls the GAC change-out frequency. The numbers aren't additive as the more adsorbable contaminants are included in each number.

	1,2,3-TCP	**1,2-DCA**	**CCl_4**	**TCE**	**PCE**
Bituminous Coal	1,825,000	1,648,390	1,381,150	170,330	29,200
Virgin Coconut	1,022,000	912,500	762,690	94,630	16,220
React & Return Coconut*	1,390,475	982,692	851,670	105,145	18,025

Breakdown of Carbon Usage per Chemical for Different Carbon Types Proposed by U.S. Filter

Table 1- Usage per Compound per Year (lbs/yr)

Compound	**Bituminous Coal**	**Virgin Coconut**	**React & Return Coconut**
CCl4	1,210,820	668,060	746,525
1,2-DCA	267,240	149,810	131,022
1,2,3-TCP	176,610	109,500	407,783
TCE	141,130	78,410	87,120
PCE	29,200	16,220	18,025

Table 2 - Usage per Compound per Day (lbs/day)

Compound	**Bituminous Coal**	**Virgin Coconut**	**React & Return Coconut**
CCl4	3,317	1,830	2,045
1,2-DCA	732	410	359
1,2,3-TCP	484	300	1,117
TCE	387	215	239
PCE	80	44	49

Note: Values in Tables 1 and 2 are additive.

Breakdown of Carbon Usage per Chemical for Different Carbon Types Proposed by Calgon Carbon

WaterAds Results

Calgon Carbon Corporation WaterAds Report

Temperature (F): 60.0 Flow Rate (gal/min): 7000 3/29/06

Pressure (atm): 1.0

Adsorbate (Listed In Order of Elution-First is on Top)	Concentration (ppm)	Adsorbent Use Rate (lbs/day) CCC Carbsorb 30	CCC F200	CCC F300	CCC F600	CCC OLC
Carbon Tetrachloride	0.02	1428.211	1001.069	1012.153	857.871	1191.798
1,2-Dichloroethane	0.0025	952.167	678.999	685.999	582.857	777.043
Trichloroethylene	0.02	261.890	194.680	196.328	167.800	202.635
Tetrachloroethylene	0.008	50.676	38.481	38.770	33.238	38.165
Totals:	5.05E-2					

Note: This information has been generated using Calgon Carbon's proprietary predictive model. No safety factors have been incorporated into these results. Appropriate safety factors should be applied as necessary. There is no expressed or implied warranty regarding the suitability or applicability of results.

g/100g | g/100ml | ml/100g | ml/100ml | Use Rates | Bed Volumes | Print | Exit

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Carbon Tetrachloride	0.02	1463.596	1025.895	1037.253	879.145	1221.219
1,2-Dichloroethane	0.0025	990.133	705.690	712.982	605.733	808.521
Trichloroethylene	0.02	321.006	236.773	238.859	203.925	250.869
1,2,3-Trichloropropane	0.000014	190.267	141.714	142.901	122.171	146.861
Tetrachloroethylene	0.008	50.679	38.483	38.773	33.240	38.167
Totals:	5.05E-2					

Note: This information has been generated using Calgon Carbon's proprietary predictive model. No safety factors have been incorporated into these results. Appropriate safety factors should be applied as necessary. There is no expressed or implied warranty regarding the suitability or applicability of results.

g/100g | g/100ml | ml/100g | ml/100ml | Use Rates | Bed Volumes | Print | Exit

Notes: The adsorbent usage rates in these tables are not cumulative. The last category identified by "CCC OLC" is the virgin coconut type.

Breakdown of Carbon Usage per Chemical for Different Carbon Types Proposed by Shaw/Basin

Table 1 - Usage per Compound per Day (lbs/day)

Compound	**Bituminous Coal**	**Virgin Coconut**
CCl4	3,100	2,170
1,2-DCA	3,580	2,506
1,2,3-TCP	274	192
TCE	1,690	1,183
PCE	946	662

Note: Values in Table 1 are additive.